SEP 9 1924

No. 5. Vol. XVII. May, 1924.

The ILLUMINATING ENGINEER

ELECTRICITY · ACETYLENE · OIL · GAS

Edited by LEON GASTER

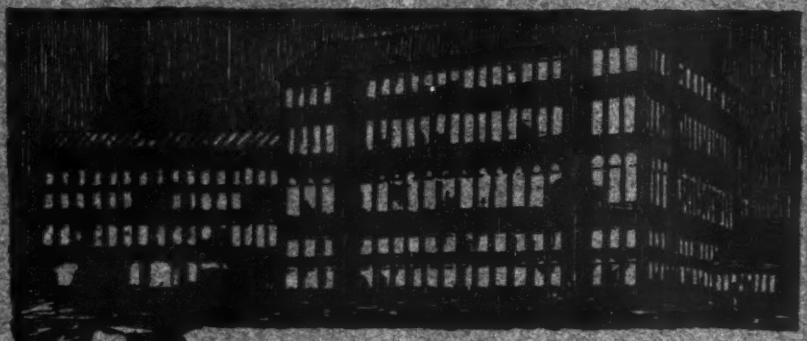
18/- Yearly. THE JOURNAL OF SCIENTIFIC ILLUMINATION. 1/6 a Copy.

OFFICIAL ORGAN OF THE
Illuminating Engineering Society.
(Founded in London 1909.)

ILLUMINATING ENGINEERING PUBLISHING COMPANY, LTD.
32, VICTORIA STREET, LONDON, S.W.1
(TEL. No. VICTORIA 5215.)

Special Textile Lighting Issue

This number contains the papers presented by MR. ERNEST L. OUGHTON and MR. P. J. WALDRAM, at the Meeting of **The Illuminating Engineering Society** on April 28th, 1924, dealing with the **Lighting of Textile Works** (*a*) **by Gas,** and (*b*) **by Daylight.**



THE GAS LIGHT AND COKE COMPANY

will be happy at any time to co-operate fully with any Member of The Illuminating Engineering Society in the planning of the lighting of any room or building situated within their area of supply, and in making any experiments in connection therewith to the end of ensuring its illumination on scientific and practical lines.

Communications addressed to the Chief Office, Horseferry Road, Westminster, S.W.1, and mentioning "The Illuminating Engineer," will receive special attention.

The ILLUMINATING ENGINEER

ELECTRICITY · ACETYLENE · OIL · GAS

Edited by LEON GASTER

THE JOURNAL OF SCIENTIFIC ILLUMINATION.

OFFICIAL ORGAN OF THE

Illuminating Engineering Society.

(Founded in London, 1909.)

ILLUMINATING ENGINEERING PUBLISHING COMPANY, LTD.

32, VICTORIA STREET, LONDON, S.W.1.

Tel. No. Victoria 5215.

EDITORIAL.

The Lighting of Textile Mills.

The lighting of textile mills is a subject which those of us who work in the vicinity of London have few opportunities of studying. The papers presented before the Illuminating Engineering Society on April 28th were therefore intended as an introduction to a future discussion at one of the great textile centres.

The paper by Mr. E. L. Oughton deals with gas lighting, on which little has been written. Though now associated with the South Suburban Gas Company, Mr. Oughton has had special opportunities of studying lighting conditions in the textile mills of Bradford and the vicinity. His paper contained a general survey of modern methods of gas lighting for this purpose. Mr. P. J. Waldram's paper deals with some of the complex considerations affecting access of daylight Electric Lighting of Textile Mills will, it is hoped be dealt with on a future occasion.

Textile lighting presents many problems that are common to the use of all illuminants. Chief amongst these is the effect of the bulky machinery and relatively low ceilings, rendering completely successful overhead lighting difficult. Only those with full knowledge of these intricate processes can appreciate how each requires special treatment in order that ample

illumination may be available at the essential point, and that the observation of the yarn and the prompt repair of breakages may be facilitated. Taking into consideration these conditions the writer has suggested that provision should be made for the mounting of special local units, and that this requirement should be born in mind in the design of the machine.

There are other special problems mentioned by Mr. Oughton. Lighting fittings must be able to withstand the damp atmosphere prevalent in the dyeing, scouring and milling and other sections, hence lamps constructed of copper are preferably used in such departments. Again, the liability of fluff in the atmosphere to choke burners must be guarded against; Mr. Oughton refers to several processes of high pressure lighting in which the air-supply for the burner is taken direct from outside the building. A point of great importance is the effect of the dark material often used in the textile industry. Naturally, such material requires an illumination very much higher than when light material is used; in fact tests have shown that the scientific method of dealing with this is to aim at *constant brightness* of material. It would appear therefore that the lighting should be adapted to meet the most severe requirements that may arise, and that the intensity of illumination should be adjustable according as light or dark material is used.

The natural lighting of textile mills offers problems quite as complex as those involved in artificial lighting. In modern mills special efforts are made to ensure maximum access of daylight, but many buildings of older date are less satisfactory. Mr. Waldram points out that in spinning operations the yarn is severely handled and everything possible must be done to keep the material supple and tenacious. This involves the maintenance of a high temperature and humidity, such as would be almost impossible to obtain in top-lit sheds. Side-lit rooms are, therefore, inevitable and even in this case the special conditions set a limit to the permissable size of windows. In the case of weaving operations the requirements as regards temperature and humidity are less exacting, but lighting problems are still linked up with the question of ventilation.

Access of daylight is commonly rated in terms of the daylight factor (the ratio between the illumination at the point of work and the unrestricted illumination out of doors). Mr. Waldram raises an interesting point in this connection—the question of the plane of measurement. In ordinary practice the horizontal plane, the most important for the great majority of industrial processes, is taken. But in the case of spinning floors it is suggested that light falling on a vertical plane is most important; with side-lit rooms measurements in a vertical plane would presumably give considerably higher values for the daylight factor.

These two papers have served a valuable purpose in indicating lines of further discussion. Textile processes provide a very clear example of the need for consultation between lighting experts and those engaged in the industry. Hence the proposed conference at a textile centre should yield valuable results.

The Action of Light on Coloured Materials.

A matter of considerable importance to the Textile Industry is the permanence of colour of pigments used for dyeing fabrics. It is common knowledge that many of the colours produced in the emergency arising from the war proved to be distinctly fugitive. It may be recalled also, that Sir Sydney Harmer, Direction of the Natural History Section of the British Museum, recently called attention to the important effect of exposure to light on the delicate colours of many objects in museums. Experiments so far conducted seem to show that it is mainly the light in the blue and ultra-violet region of the spectrum that is responsible. Fading of colours is essentially a chemical effect, called into play by the action of light, and it appears that the presence of moisture and oxygen are important factors.

Sir Sydney Harmer's experiments led to the general conclusion that exposure to direct sunlight is more injurious to colours than exposure to diffused daylight; and that diffused daylight is itself more active than light from incandescent electric lamps. It is evident, however, that illuminants differ greatly in this respect and the problem of finding a standard artificial source for experiments in fading deserves attention. Tests conducted by sunlight may have to be prolonged for weeks or months, and the matter is complicated by the extreme variability of climatic conditions. According to some experiments recently conducted in the United States the quartz tube mercury arc lamp was found to be the most powerful fading agent, much more so than the carbon arc or sunlight. Incidentally, the tests revealed remarkable differences in the effect of sunlight in different areas; the sun in New Jersey was distinctly more powerful than in Arizona. This is another reason for desiring an artificial fading standard. But it is necessary to proceed warily. It was found that whilst very many dyes are more rapidly affected by the mercury arc than by sunlight, there are some pigments for which the reverse is true. Hence, it would seem that the regions of the spectrum most powerful in producing fading may vary according to the nature of the dye employed.

Assuming, however, that a certain range of colouring materials is habitually employed it should be possible to devise a test by artificial light which will serve as a fair indication of the degree of fading likely to occur in practice. In a recent paper before the Illuminating Engineering Society (U.S.A.) it was stated that an enterprising advertising concern has devised a test with an arclight for use in connection with lithographic bill-posters. From these tests it was deduced that an exposure of 50 hours to the arc was roughly equivalent to the average exposure to daylight during three to four weeks—the average length of the bill-posting campaign. In Washington the public printer employs a fading machine to test the light-resisting properties of materials used for Government publications, and leading manufacturers of paints and varnishes already arrange for a test of permanence of colour and the usual " weathering " test to proceed simultaneously.

There must be many industries, besides the textile industry mentioned as an obvious example, which would find a standard test of colour-permanence of great value and the whole subject deserves further investigation at the hands of research associations working in conjunction with the Illuminating Engineering Society.

The Influence of Light upon Vegetation.

Gardeners are well aware of the effect of light on plant growth. It is common knowledge that many flowers will bloom but sparsely, or may not bloom at all, in shady gardens and that in general bright sunlight is necessary to get good results. It is natural, therefore, that the possibility of using artificial light should have been considered, and there have been many experiments in this direction in the past. Many of these investigations were made at a time when it was difficult to obtain artificial light in great quantity and the negative results in some cases may be ascribed to the fact that the illumination was too low, in comparison with the very high intensity of daylight, to produce much effect. More recently experiments have been made with relatively high illuminations, and some instances of remarkable stimulus to growth have been recorded.

Some interesting experiments in this direction are summarised in two papers by Mr. R. B. Harvey and H. Findlay read before the Illuminating Engineering Society. The light was provided by gasfilled tungsten lamps, and the illuminations provided ranged from about 300 to 1500 foot-candles. This exposure was supplementary to natural illumination. At noon-day the illumination from sunlight may attain nearly 10,000 foot-candles, but it is thought that this is probably higher than is desirable for cultivation of plants.

The experimenters agree in finding that the addition of artificial light had a marked effect, in hastening the growth of seedlings and cuttings; and that, provided each plant is given sufficient space for normal development and proper soil, moisture and temperature conditions are maintained, the more rapid growth and development is not attended by weakness or spindly formation. The most striking effect of the increased light, however, appears to be in hastening the time of blooming. It is stated that on the average flowering plants came into bloom eight days earlier than when no artificial light was used. It is also claimed that the use of abundant light helps to check liability to fungus and disease.

On many points—for instance the effect of variation of *colour* of light—much remains to be learned. Experiments so far conducted in this field appear to have led to somewhat inconclusive results, largely because sufficient account was not taken of the fact that the use of coloured glass is attended by a great diminution in intensity of light. Mr. J. H. Zimmerman, in giving some particulars of the lighting equipment, considered that the cost was not excessive provided large numbers of plants are treated on a sufficient scale. Mr. Harvey was disposed to doubt whether artificial light would be used in the near future for the growth of crop plants on a commercial scale, but that it might find a valuable application for the purpose of blooming rare and valuable plants out of season. There is also the possibility that the installation of abundant artificial light might enable an adequately ventilated cellar to be used as a greenhouse, though it has still to be shown whether plants can be raised exclusively by artificial light. It is stated that experiments on this subject are proceeding at a number of agricultural experiment stations in the United States and it is to be hoped that similar confirmatory investigations, on a sufficiently large scale, will also be made in this country.

L. GASTER.

TRANSACTIONS

OF

The Illuminating Engineering Society.

(Founded in London, 1909.)

The Illuminating Engineering Society is not, as a body, responsible for the opinions expressed by individual authors or speakers.

SOME PROBLEMS IN THE LIGHTING OF TEXTILE MILLS.

A MEETING of the Society was held at the House of the Royal Society of Arts, 18, John Street, Adelphi, W.C., at 8 p.m. on Monday, April 28th, Mr. L. GASTER presiding.

The Minutes of the last meeting having been taken as read, the HON. SECRETARY announced the names of the following applicants for membership:—

HARRINGTON, J.	Electrical Engineer and Contractor, 4, Albany Street, London, N.W.
IVES, R. A.	Engineer, Benjamin Electric Ltd., Brantwood Works, Tariff Road, Northumberland Park, Tottenham, N.17.
SCHNEIDER, A.	Electrical Engineer, 13a, Ringgatan, Malmo, Sweden.
TINGLEY, G.	Electrical Engineer, 1, Danecroft Road, Herne Hill, London, S.E.24.
WILSON, G. H.	Tech. Asst., Research Laboratories, The General Electric Co., Ltd., Wembley.
WOOD, L. A. S.	Manager, Illuminating Section, Westinghouse Electric and Manufacturing Co., Ltd., South Bend, Indiana, U.S.A.

The names of applicants announced at the previous meeting were read out again and these gentlemen were formally declared members of the Society.

THE CHAIRMAN then called upon Mr. ERNEST L. OUGHTON to read his paper entitled **"Some Problems in the Lighting of Textile Mills by Gas."** Mr. OUGHTON described typical systems of modern gas lighting and explained by the aid of numerous slides showing photographs of installations and sketches how the varied requirements of different textile processes could best be met. In the subsequent discussion THE CHAIRMAN (Mr. L. GASTER), Mr. J. G. CLARK and others took part, and Mr. OUGHTON briefly replied. A paper by Mr. P. J. WALDRAM dealing comprehensively with the Daylight Illumination of Textile Mills was taken as read, and in conclusion THE CHAIRMAN announced that the Annual Meeting would be held on May 26th.

SOME NOTES ON GAS LIGHTING IN THE TEXTILE INDUSTRY.

By Ernest L. Oughton.

(*Gas Sales Superintendent, South Suburban Gas Company.*)

(Paper read at the meeting of the Society held at the House of the Royal Society of Arts, John Street, Adelphi, London, W.C., at 8 p.m. on Monday, April 28th, 1924.)

Introduction.

In presenting these notes to the Illuminating Engineering Society, acknowledgment is gladly made of the great help the writer has derived from its transactions in past years.

One of the difficulties experienced in its preparation is the unavoidable overlapping of subject matter already ably given.

It is proposed to approach the subject more from the practical illuminating standpoint rather than the ultra-scientific method, concerning which the Society's records are already replete.

No apology is needed for placing the gas standpoint before you; in the first place, because this Society is an unbiassed Illuminating Engineering Society, and, secondly, we firmly believe that gas lighting correctly applied is able to meet the most exacting requirements of illuminating science, as well as the mundane consideration of £ s. d. Also it meets the demands of the Medical Eye Specialists and is not found wanting where hygenic conditions are required.

The development in gas lighting is remarkable when it is remembered that the nominal effective duty has increased from 3 candlepower per cubic foot of gas consumed in flat-flame burners to approximately 50, an increase of 1,600 per cent.

In looking through the exhaustive Report of the Home Office Departmental Committee on Factory Lighting, the writer finds there are no references to mills in the area where he was engaged for some years, and had experience with nearly every type of gas lighting from flat-flame burners in the earlier years, to high-pressure systems and the modern development of low-pressure superheated burners.

The following résumé of some of the different systems which came under observation may be of interest to those who have not had the opportunity of personal experience.

Flat-flame Burners.—Several mills were found to have the obsolete flat-flame burners still in use, their only advantage being the facility for lighting the surreptitious cigarette; these have now been replaced with high-pressure gas lighting.

The flat-flame burners were fixed very low down, and in some cases were attached to the machines, while illumination was not considered; therefore, the lighting was deplorable. The best type did not give a duty exceeding 3 candlepower per cubic foot burned, and 16 candlepower on the horizontal while the mean spherical candlepower was 13·6 (Wedding).

Low-pressure Upright Incandescent Burners.—Low-pressure upright "C" burners were in use with and without reflectors—though in many cases the reflectors were so dirty that the illumination was chiefly horizontal, leaving the working plane very deficient. These gave a duty of 15 to 18 candlepower per cubic foot of gas consumed, which very soon deteriorated owing to mantles breaking off at the bottom and the vibration caused them to be suspended out of the vertical axis and only partially incandescent. The "C" mantle is too broad at the shoulder and does not conform to the flame structure of a well aerated flame.

The Kern and Visso mantles have not this fault, and so give higher duties. The horizontal candlepower of a "C" burner is about 65-70 candlepower, while the mean spherical candlepower is 46 without reflector.

High-Pressure Burners (Upright).—The Keith upright type high-pressure burners operated by water motor, and maintained at a pressure of 10 ins. water

gauge pressure was in use in several mills and were a great improvement on the low-pressure "C" burners where the reflectors and burners were kept in good condition. The chief units were nominally 150 and 300 candlepower, and gave a duty of 30 candlepower per cubic foot of gas used, the degree of illumination on the working plane being dependent upon the type of shade and spacing, which were generally efficient. These mantles conformed to the flame structure of the bunsen burner.

High-Pressure Inverted Burners.—The original Selas system of upright burners was also in use, these were changed later to the inverted type. In this system the gas and air are mixed in a machine in the air-gas ratio of 1½ to 1, and distributed at a pressure of 10 ins. (water), the average duty being 40-45 candlepower per cubic foot in the inverted type.

We also had installations of the Textile Illiminating Engineering Company, of Manchester, inverted high-pressure type. This system is worked at 6-8 ins. pressure (water). The burners are provided with a special dust trap and gauze to prevent fluff being drawn into the burner, and are made in three sizes, viz., 2, 2½ and 3½ c. ft. per hour and give 40-45 candlepower per cubic foot. The burners remain lighted at a lower efficiency should the compressor stop from any cause—which obviates panic and accidents.

The Keith upright burners in some instances have been converted to their new Textile System of inverted mantles, which give a certain amount of upward illumination and the light is maintained when the compressor stops running.

Many mills are using the Keith 54 in. and 81 in. (water) inverted high-pressure burners and range in candlepower from 60 to 500 candlepower units, and have an average useful duty of 45-50 candlepower per cubic foot of gas used. The diversity of candlepowers enables any foot-candle illumination to be given under any circumstances. The mantles in general use are the uncollodionised or soft type, which conform to the flame shape. The polar curve determination depends upon the type of shade or reflector used.

Another system of inverted high-pressure is the Selas-Turner "whole mixture."

In this system the gas and air are mixed at 10 ins. water column so as to be a "self-burning" mixture, no air being taken in at the burners, provision being made in its construction to prevent any "flashing back." The gas consumption of a 100 candlepower unit is 2 c. ft. per hour. The dimensions of a 100 candlepower unit are 1¾ ins. long and ⅝ ins. diameter. The advantages of this system are that the burner is unaffected by dust or fluff which may be floating in the air of the room, also the lights may be lowered without difficulty, while the absence of gauzes eliminates the major maintenance charges.

Other well-known systems of high-pressure lighting have been omitted only because they have not come under the author's personal observation.

High efficiency in gas lighting is not limited now to high-pressure systems, as very great advance has been made in low-pressure burners and lamps.

Mention may be made of a small installation of "Mundas" light, in which the burner nozzle has a perforated end and extends about two-thirds into the mantle of special shape. The candlepower per cubic foot is increased from 25 candlepower on the horizontal to a maximum of 43-45 candlepower between 70 degrees and 90 degrees below the horizontal, *vide*, Prof. V. B. Lewis.

The latest system of high efficiency low-pressure lighting is that developed by Messrs. W. Sugg and Co., Ltd., in which the gas and air mixture is preheated in a superheating chamber directly over the mantles, No. 1 and No. 2 size being used.

This system gives a duty under working conditions of 40-50 candlepower per cubic foot, with a pressure of 25/10 ins. (water). See polar curves.

The gas and air inlet ports are covered with a gauze screen to prevent dust and fluff being drawn in.

The great strides made in low-pressure gas lighting pertinently points to an increasing need of discrimination as to which system should be installed.

There are instances where high-pressure should be used, yet with the keen competition prevalent, initial capital cost,

maintenance and running charges have to be considered very seriously.

General Considerations.—Textile Mill lighting should be arranged to allow for a minimum "general" lighting as distinct from the local lighting of the machines and should be separately controlled in each floor or room.

Where high-pressure gas is used other than the 6-8 in. Textile systems, it is advisable to have a number of low pressure units in each room directly connected to a separate supply, so as to avoid panic and accidents in the event of the high-pressure supply failing from any cause.

The lighting units should not be arranged on empirical rule of thumb methods, because illuminating science has demonstrated without doubt that scientific lighting can reduce actual lighting costs, increase the standard and output of work, improve the health and comfort of the operative and minimise the number of preventable accidents.

Where a good daylight illumination is provided, as in modern factories with North light roof illumination, the hours of artificial lighting are necessarily lessened and the artificial illumination should be higher in order that the diversity of daylight and artificial lighting should not be too great.

The hours of artificial lighting being less, compensates for the higher illumination.

Many mills have been observed to need artificial lighting nearly all the year round. This state of affairs tends towards causing the workers to be satisfied with a much lower illumination, to the detriment of their eyesight and the standard of work produced.

From the Home Office Report we find that the average daylight factor observed was 2 per cent., *i.e.*, the percentage of light actually received, compared with the light which would be received if the walls were removed. In a few cases it reached 1/10th, but more often lay between 1/100th and 1/1,000th of the outside illumination, which varies from 4,100 foot-candles (mean) at mid-day in June to 720 foot-candles (mean) midday in December. In on case the outside illumination was as low as 105 foot-candles.

The relation between daylight and artificial illumination in a woollen mill was as follows :—

	Outside.		Inside.	
	Foot-candles		Foot-candles.	
	max.	min.	max.	min.
Daylight illumination	770	730	4·4	0·84
Artificial illumination	—	—	2·0	1·40

The following relate to processes in Woollen Mills :—

Process.	Daylight.		Artificial.	
	Foot-candles.		Foot-candles.	
	max.	min.	max.	min.
Scribbling	20·3	2·1	0·48	0·15
Winding	28·0	11·9	4·0	0·61
Mules	63·0	·21	3·4	0·56
Finishing	42·0	2·1	4·6	0·67

Causes of unsatisfactory illumination, *vide*, Report 1915.

(1) The provision of too few or too weak light sources.

(2) Antiquated methods of lighting.

These causes of complaint are rapidly dying out, for, though some employers may be indifferent to the worker's welfare, the increasingly keen competition at home and abroad demands maximum output and standard of work, and to obtain this adequate illumination becomes a necessity.

Gas undertakings also realise that indifferent lighting in factories involves the inevitable loss of the business, so now inspect gas lighting installations and advocate modern systems.

(3) Inadequate supply.

(4) Neglect of upkeep.

These are now of rare occurrence and are indefensible as the gas undertakings generally have a specially trained staff for this work, and undertake it at a low figure.

(5) Inside obstruction.

(6) Shadows and placing of lights.

These can be remedied as far as artificial illumination is concerned, by taking each machine separately and replanning the installation, and if the primary laws of illuminating engineering are observed

shadows may be eliminated, whether due to the obstruction of the machines or faulty spacing of the lighting units.

The perpetuation of the foregoing faults inevitably leads to accidents, impaired eyesight and health, with reduced standard of work as regard quality and quantity.

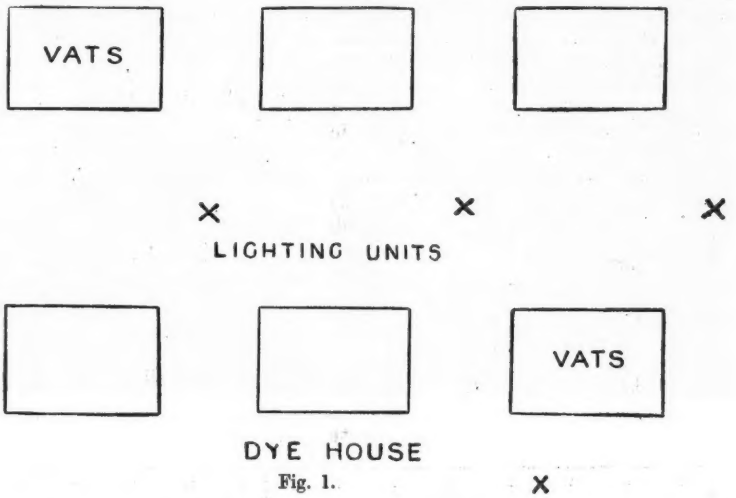


Fig. 1.

The standard of minimum illumination in mills working on materials with different coefficients of reflection should always be based on that giving the lowest reflection.

This was emphasised during the war period, 1914-1918, when the writer had to materially increase the lighting of several mills, where previously light coloured material was made, because of their going over to spinning and weaving dark grey and black materials. In some cases the illumination had to be more than doubled.

An example of the importance of taking account of the coefficient of reflection is given in the 1915 Report as follows :—

"Grey cloth having a coefficient of 20 per cent. is illuminated to 5 foot-candles. Its surface brightness would be matched by a perfectly white surface illuminated to

$$5 \times \frac{20}{100} = 1 \text{ foot-candle.}$$

The equivalent surface brightness of grey cloth under these conditions is thus said to be 1 foot-candle."

NOTES ON VARIOUS PROCESSES.

Dyeing.—The atmosphere of a dye house, whether yarn or piece dyeing, is generally full of vapour from the boiling liquids in the vats and the removing

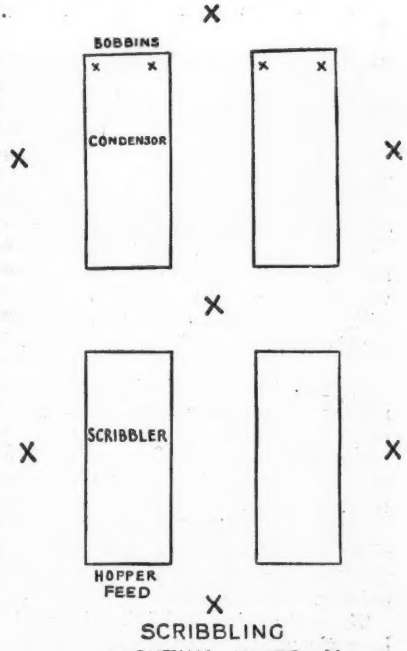


Fig. 2.

of materials after dyeing, and in many instances it has been noticed that the daylight illumination is very low and artificial light is needed to a very large extent.

Large units are necessary and usually fixed well up if there is head room.

We have used with great success low-pressure copper lamps with superheated burners and No. 2 mantles, of the outside type, the heated globe preventing condensation on its surface.

Scribbling.—These are large machines working in pairs, tandem fashion, in which the raw material is scribbled and carded and run on to condenser bobbins prior to the spinning. High candlepower units fixed well above the machines, where possible, give the best results, with smaller units over the condenser bobbins as shown in diagram. (See p. 69.)

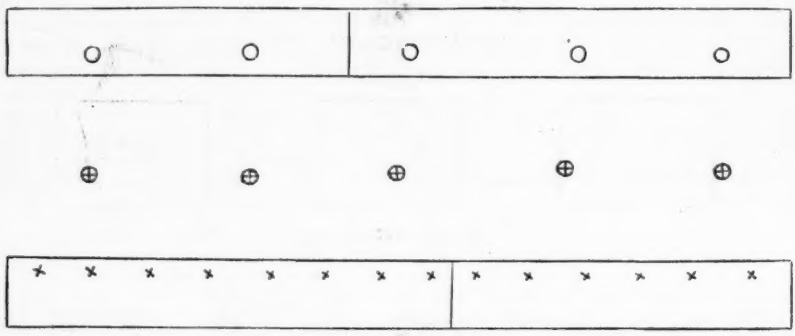
Mule Spinning.—Spinning mules are usually arranged in parallel, the length varying from approximately 40 ft. to 110 ft. with the head stock, and the width of the mule gate is generally between 16 ft. and 18 ft.

Good illumination is necessary especially when spinning dark yarn to enable the "piecers" to find the broken ends quickly.

The best method of lighting these is to have the units over the centre of the draw rollers.

Another method much used where there is good headroom is to have large units fixed down the centre of the mule gate, though, if, as is often the case, the head room is low, the piecers have to work in their own shadow, which obviously ought to be avoided. The "fine work" minimum should be observed, viz., 3 foot-candles, though 5 foot-candles is not too much where varied shades of yarn are used.

Winding, Warping, etc.—The work of winding, twisting, warping, and healding are processes of preparing yarn or warps for weaving in the looms.



LIGHTING UNITS A-x, B-⊕, C-O.

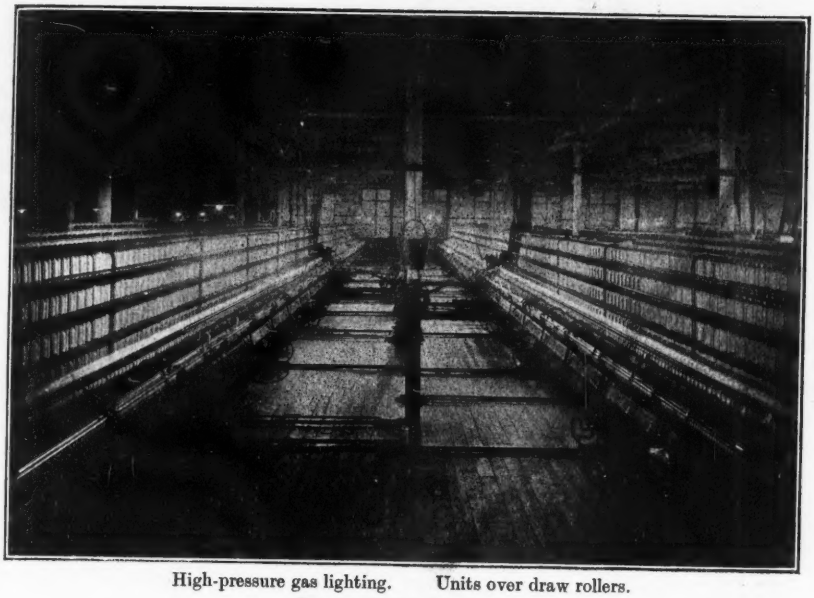
MULE SPINNING

Fig 5.

A good illumination is necessary to detect defective and broken threads and 3-5 foot-candles should be given.

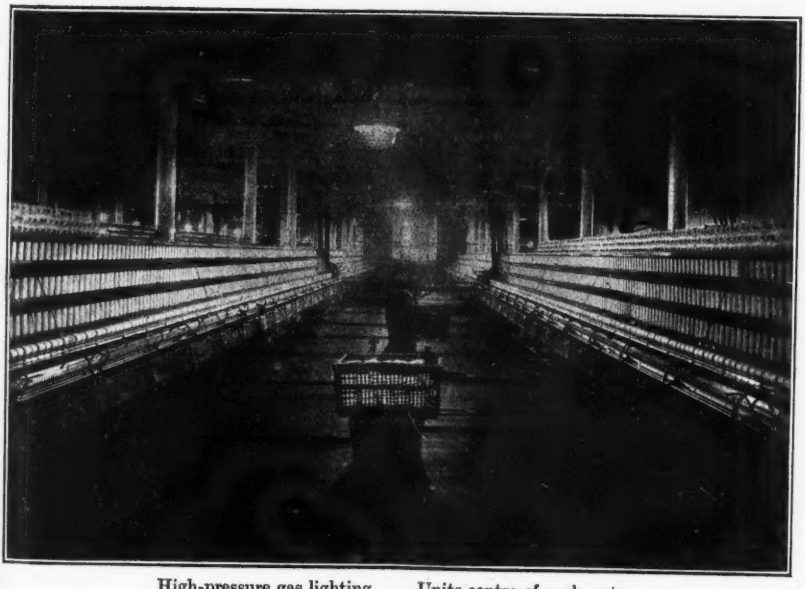
Weaving.—This is the conversion of the yarn into cloth, and needs very good illumination over the working plane to observe defects in the threads, and based on the material having the lowest co-efficient of reflection. Modern looms have greatly increased speed as well as the number of picks per minute, which demand a higher degree of illumination. The looms are placed so that the "fronts" of each two looms face each other and form the loom gate, where the two weavers work back to back. The backs of the looms form the back alley.

The lighting units must be so placed that neither have to work in shadow.



High-pressure gas lighting. Units over draw rollers.

Fig. 3 —MULE SPINNING



High-pressure gas lighting. Units centre of mule gate.

Fig. 4.—MULE SPINNING

Perching and Mending in Grease.—This process is the inspection and mending of defects in the woven materials before finishing. Two menders sit side by side at an oblique table over which the cloth is passed. High illumination is necessary as the eye strain is very great with dark materials should it be insufficient.

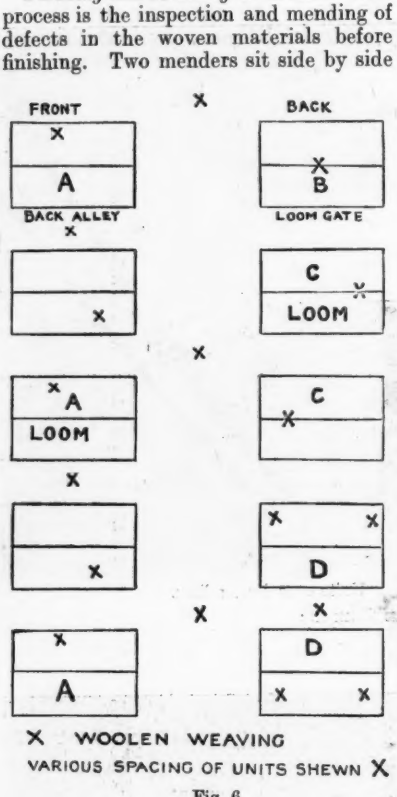


Fig. 6.

The unit is usually fixed midway between the menders, and should direct the light over the whole width of the cloth under inspection.

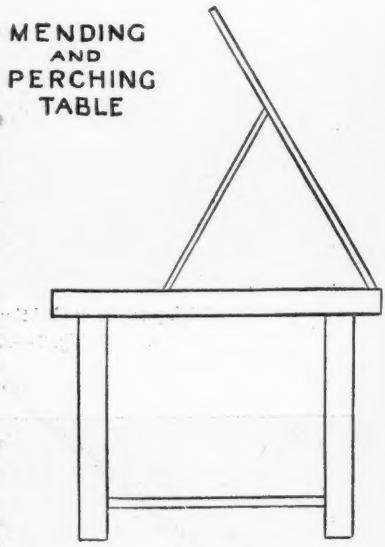


Fig. 8.

Scouring and Milling.—This process removes the grease and scours the

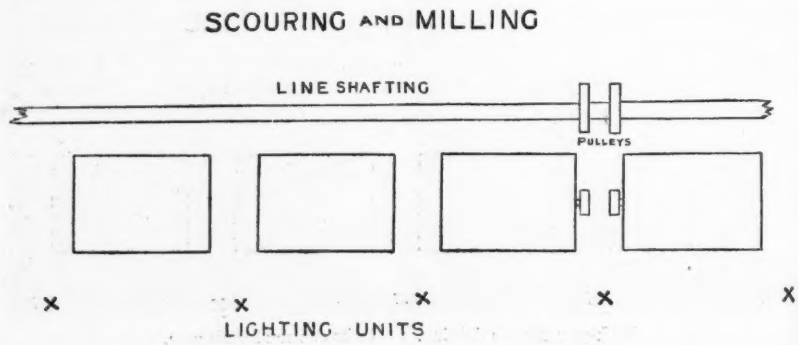


Fig. 9.

materials by passing them through hot water and soap.

Many of these rooms have been found to have very low daylight illumination.

As the atmosphere is damp we have often fixed copper lamps similar to those in the dye house, though of lower candle-power, the process not demanding a high illumination.

Tentering.—This process is the removing of the moisture from the cloth and stretching it. The work is practically automatic and does not need special illumination; a good general illumination is applied. The machines are often large and obstruct daylight.

Finished Mending and Perching.—This is the final mending operation and is dealt with in the usual mending room previously described.

Cropping, Brushing, Moser Raising, Blowing and Pressing.—These are processes in the finishing department giving different surface finish to the cloth, as nap raising and treatment of velures.

These machines need a good general illumination in addition to definite local lighting.

Perching.—This is the final examination of the completely finished material before being sent to the warehouse. Lighting similar to the mending room tables is required.

Warehouse.—Good general lighting with the units high up is essential for the illumination of the warehouse, and where there is a cutting table for small orders a good local lighting over the table should be given.

High-pressure gas lighting. Units over frames.

Fig. 7.—WINDING.

Illumination data of processes shown in the "line sketches."

(NOTE.—The varying coefficient of reflection must be calculated in any practical application of the following data.)

Dyehouse.—Assume vats to be 9 ft. by 6 ft. and 2 ft. 6 ins. high and placed 6 ft. apart, the gangway being 10 ft. wide.

The light units are fixed 10 ft. from floor and midway between vats and gangway.

The lamps are copper of the outdoor pattern. Gas consumption 12·5 c. ft. per hour at 25/10th pressure. Calorific value of gas 500 B.Th.U. per cubic foot.

The hemispherical polar curve of the unit is :—

230	candlepower	on the	horizontal.			
375	,,	,,	20	degrees	below	horizontal.
435	,,	,,	30	,,	,,	,,
475	,,	,,	40	,,	,,	,,
510	,,	,,	50-70	,,	,,	,,
500	,,	,,	80-90	,,	,,	,,

The illumination received from the 2 lamps is (*a*). Front edge of vat at centre line back to front—

$\theta = 50°$ $Eh = I\,Cos^3\,\theta \div h^2 \times 2 = 475 \times Cos^3\,50° \div 7{\cdot}5^2 \times 2 = 475 \times {\cdot}265 \div 56{\cdot}25 \times 2 = 4{\cdot}46$ foot-candles.

(*b*) Centre of vat—

$\theta = 57°$ $450 \times {\cdot}161 \div 56{\cdot}25 \times 2 = 2{\cdot}56$ foot-candles.

(*c*) Back edge of vat at centre line back to front—

$\theta = 62°$ $425 \times {\cdot}103 \div 56{\cdot}25 \times 2 = 1{\cdot}54$ foot-candles.

This example is given rather more in detail to show method of arriving at illumination.

Weaving.—Looms 12 ft. 9 ins. long 5 ft. 6 ins. back to front, working approximately 2 ft. 6 ins. from floor. Gangway 8 ft. wide. Loom gate 2 ft. 3 ins. Back alley 1 ft. 9 ins.

Method of spacing units :—

(*a*) Over front of looms alternately 9 ins. from centre line. Back alleys centre. Units 150 candlepower high-pressure with enamelled shade. 3 c. ft. per hour. 7 ft. 6 ins. from floor.

(*b*) Over centre of loom, well up. No unit in back alley. Unit 300 candlepower high pressure, 5·5 c. ft. per hour, 8 ft. from floor.

(*c*) Similar to B only alternately 3 ft. from centre line.

(*d*) Two smaller units over front of each loom, 4 ft. 6 ins. from centre line. 1 unit in back alley.

Units 60 candlepower high-pressure 1·5 c. ft. per hour in each case. 6 ft. 6 ins. from floor. Gangway lighting approximately 20 ft. centres. 150 candlepower high-pressure units 3 c. ft. per hour, 8 ft. from floor.

Mule Spinning.—Total length 90 ft. Width of mule gate 16 ft.

Method of lighting :—

(*a*) Two rows of 14-60 candlepower high-pressure burners with enamelled shades, fixed at 6-7 ft. centres over the draw rollers. 7 ft. from floor. Consumption of units 1·5 c. ft. per hour. Calorific value of gas 500 B.Th.U. per cubic foot.

Total consumption 42 c. ft. per hour. Polar curve not available.

(*b*) One row of 5-500 candlepower high-pressure lamps down centre of mule gate, fixed at 16 ft. centres. 8-10 ft. from floor. Consumption of units 9 c. ft. per hour. Total consumption 45 c. ft. per hour.

Polar curve for the lamps with shallow reflectors :—

430	candlepower	on the	horizontal.			
525	,,	,,	20	degrees	below	horizontal.
550	,,	,,	30	,,	,,	,,
525	,,	,,	40	,,	,,	,,
500	,,	,,	50	,,	,,	,,
450	,,	,,	60	,,	,,	,,
300	,,	,,	70	,,	,,	,,

(*c*) Two rows of 5-150 candlepower high-pressure lamps fixed over draw rollers at 16 ft. centres, 7 ft. from floor.

Consumption of units 3 c. ft. per hour each. Total consumption 30 c. ft. per hour. Polar curve shown elsewhere.

(*d*) Two rows of 5 low-pressure lamps with open silica globes, fixed over draw rollers at 16 ft. centres, 7 ft. from floor.

Consumption of units (3 bijou mantles) 5 c. ft. per hour. Total consumption 50 c. ft. per hour.

Polar curve reading :—

75	candlepower	on the	horizontal.			
112	,,	,,	30	degrees	below	horizontal.
150	,,	,,	40	,,	,,	,,
212	,,	,,	50	,,	,,	,,
230	,,	,,	60	,,	,,	,,
240	,,	,,	70	,,	,,	,,
212	,,	,,	80	,,	,,	,,
200	,,	,,	90	,,	,,	,,

Scribbling.—Gangways 6 ft. wide. Light units 8 ft. from floor. Low-pres-

sure lamps 7·5 c. ft. per hour. 25/10ths pressure. Calorific value of gas 500 B.Th.U.'s per cubic foot. Lamps fitted with open silica globes. Polar curve :—

90 candlepower on horizontal.						
135	„	„	30	degrees	below	horizontal.
210	„	„	60	„	„	„
275	„	„	80	„	„	„
285	„	„	90	„	„	„

or 150 candlepower high-pressure lamps 81 ins. pressure, 3 c. ft. per hour fitted with enamelled steel shade (shallow). Polar curve :—

125 candlepower on horizontal.						
175	„	„	30-40	degrees	below	horizontal.
165	„	„	60	„	„	„
150	„	„	80	„	„	„
140	„	„	90	„	„	„

Over bobbins. Lighting units fixed 4 ft. above bobbins. One low-pressure burner, 3 bijou mantles and closed silica globe. 5 c. ft. per hour. 25/10th pressure. Calorific value 500 B.Th.U. per cubic foot. Polar curve :—

100 candlepower on horizontal.						
150	„	„	40	degrees	below	horizontal.
125	„	„	70	„	„	„
100	„	„	90	„	„	„

or 2·60 candlepower burners with deep shades (polar curve not available) 1·5 c. ft. per hour each.

Scouring and Milling.—Width of machines 6 ft. Height of machines 7–10 ft. Lighting units placed between machines to light working parts and pulleys, and fixed 10 ft. from floor. Low-pressure copper lamps, outside pattern. 10 c. ft. per hour. Polar curve :—

350 candlepower			30	degrees	below	horizontal.
400	„	„	40-90	„	„	„

Mending Table.—Tables 2 ft. 6 ins. from floor. Top of oblique board 5-6 ft. from floor. Lighting unit 7 ft. 6 ins. from floor fixed over centre of board. One 300 candlepower high-pressure lamp with enamelled shade. 5·5 c. ft. per hour. Polar curve :—

160 candlepower on horizontal.						
270	„	„	10	degrees	below	horizontal.
300	„	„	20	„	„	„
330	„	„	30-40	„	„	„
325	„	„	50	„	„	„
310	„	„	60	„	„	„
275	„	„	70	„	„	„
260	„	„	80	„	„	„
250	„	„	90	„	„	„

or one low-pressure superheated type lamp with enamelled shade. 7·5 c. ft. per hour. 25/10ths pressure. Calorific value of gas 500 B.Th.U.'s per cubic foot. Polar curve :—

150 candlepower			20	degrees	below	horizontal.
310	„	„	30	„	„	„
335	„	„	40	„	„	„
375	„	„	50	„	„	„
390	„	„	60	„	„	„
450	„	„	70	„	„	„
480	„	„	80	„	„	„
490	„	„	90	„	„	„

In conclusion we would submit that gas lighting, if scientifically applied, is well able to meet all the requirements of the Home Office Committee on Factory Lighting, and also the high ideals of the Illuminating Engineering Society.

The Writer also desires to acknowledge the loan of slides by the following:—Wm. Whiteley & Sons, Ltd., Huddersfield (Textile machines); Hutchinson, Hollingworth, Ltd., Dobeross, Yorks (Looms); Keith Blackman, Ltd. (Polar curves, H.P. lamps); Wm. Sugg, Ltd. (L.P. textile burners and polar curves).

DISCUSSION.

The CHAIRMAN (Mr. L. Gaster) said that Mr. Oughton had read a most instructive paper. Although there were not any textile mills near London, the paper would serve a useful purpose in preparing the ground for discussions which it was hoped to arrange later at one of the chief textile centres in the north of England. Mr. Oughton had emphasised the fact that the Illuminating Engineering Society provided an impartial platform for the discussion of all illuminants. On this occasion an opportunity of learning something about the use of gas lighting in textile factories; on another occasion no doubt electric lighting could be similarly discussed.

He was very glad to note the importance attached by Mr. Oughton to the observance of the recommendations of the Home Office Committee, and especially the emphasis placed on pro-

viding sufficient illumination for dark materials. This was a point not always sufficiently appreciated by manufacturers who should aim at providing conditions of illumination suitable for the worst circumstances, *i.e.*, when specially dark materials had to be dealt with.

As regards standards of illumination, the working illumination necessary for various processes would have to be determined in consultation with the Joint Industrial Council of the industry. Legal minima standards of illumination were necessarily lower than values which could be recommended as desirable in the interests of efficient production. He noticed that in the latest American Code of Industrial Lighting, that introduced by the State of Washington, three distinct categories were introduced: "the minimum permissible footcandles on the work," the "recommended intensity of good practice," and the "recommended productive intensities," this last category being, for most processes, about three to four times the minimum.

The lighting of textile mills was of very great importance in view of the fine nature of the processes and the very large number of operators employed. They appreciated very much the opportunity of having a paper by Mr. Oughton, who had had special experience of this class of work.

Mr. J. G. CLARK said that it might seem strange to have a paper on the lighting of textile mills written by one who was attached to a ccompany in London, but it should be understood that Mr. Oughton had been in the north about a year ago and this paper was the result of his experience. He (Mr. Clark) had some knowledge of the subject of mill lighting, but not enough to know what the real requirements were; one must live amidst the industry, as Mr. Oughton had done, to understand all those little details which made all the difference between good and bad lighting.

One point of importance was the screening of light sources. By the aid of the silica glassware the brightness could be reduced to about 10 candles per sq. in. which he thought was a satisfactory value and which enabled the light to be used in any position without additional shading devices. Mr. Clark also alluded to the benefits of maintenance of lighting by people who were experts, and to the value of distant control. In view of the fact several times mentioned by Mr. Oughton that it was desirable to have the lights well up out of the range of view, distant control might prove specially useful in textile mills. Mr. Oughton had also alluded to the question of eliminating the entrance of dust, *e.g.*, small fibres of the materials, from clogging the burner. In this connection the Keith system of distributing an air-gas mixture, the air being supplied from outside the building, was of interest. Besides preventing trouble arising from dust being drawn into the burner, the system enabled one to use relatively low power units on high pressure; for instance, down to 30 c.p., if necessary.

Mr. Oughton had also referred to the higher illumination needed for dark yarns as compared with light yarns. If one needed, say, 5 foot-candles on white cloth, then with a material reflecting only about 20 per cent., five times the illumination, *i.e.*, 25 foot-candles, would be needed in order to get the same brightness. If such an illumination was provided it would be excessive for white cloth. Hence it would appear that the system of illumination should be adjustable according to the nature of the material used. For this purpose cluster lights, so arranged that, by merely manipulating the control tap, only some of the mantles could be used, might be useful. Alternatively the lighting could be so arranged that alternate lamps could be extinguished at will.

The thanks of the audience were due to Mr. Oughton for his interesting and instructive paper on a somewhat unusual subject.

Mr. W. M. MASON (*communicated*): The report of the Home Office Committee on the question of the lighting of factories and workshops contains the following statement of the factors which contribute to a good lighting system:—

(1) Adequacy.

(2) A reasonable degree of constancy and uniformity of illumination over the necessary area of work.

(3) The placing or shading of sources so that the light from them does not fall directly on the eye of an operative when engaged in his work, or when looking horizontally across the workroom.

(4) The placing of lights so as to avoid the casting of extraneous shadows on the work.

It is undoubtedly true that, by using either high or low pressure incandescent gas burners, all these conditions can be and are being complied with.

Economy in lighting cannot be judged solely by the saving in costs of the illuminant used. The human factor is, after all, the most important, and the object of scientific illumination should be to provide an ample light in the best possible manner, and so assist the human element to yield its best. Modern incandescent gas lighting, in the hands of the illuminating engineer, can be designed to give almost ideal conditions in textile mills and engineering shops where the lighting requirements vary from a simple general illumination system to an elaborate scheme in which the effective lighting of each of hundreds of individual threads or particular parts of machines has to be ensured.

Mr. W. A. BISHOP (*communicated*): The gas industry should be grateful to Mr. Oughton for his paper on the lighting of textile mills—a subject on which not much has been written from the gas standpoint. We, in and around London, have no opportunities of studying this problem, and I cannot therefore contribute much information on the best means of meeting requirements in textile mills.

There are, however, a few points of general interest. Such papers as that by Mr. Oughton serve to emphasise the importance of the lighting load to the gas industry. But success depends largely on recognition of the basic principle that a gas undertaking does not merely sell gas, but heat, light, power and service. Hence, the need for demonstrating to consumers the benefit of discarding obsolete fittings in favour of modern fixtures arranged in a scientific manner. Mr. Oughton indicates the possibilities in this direction in connection with textile mills, and I can confirm that when one replaces single upright burners by preheated clusters of inverted burners, one can obtain, for the same gas consumption, an increase in candlepower of about 150 per cent.

One can therefore be generous in the provision of light, and in various industrial installations in Croydon the order of illumination on benches, machines, etc., varies between 4·5 and 6 foot-candles. I am inclined to think that some of the values mentioned by Mr. Oughton for textile processes might be increased with advantage, especially when dark materials are used. I am glad to note that Mr. Oughton emphasises this point. He states that in factories converted from light to dark material the illumination had to be more than doubled. If, as appears, constant brightness of material is the principle to follow, a change from white to dark grey or black cloth might require an illumination as much as five times as great. Indeed the very high illumination needed with very dark material could probably only be provided by local illumination. In the employment of local lights complete screening of the mantle from the eyes of the worker is essential; in this connection glassware of the vitreosil type is useful, as by this means the intrinsic brilliancy can be reduced to within 10 candles per sq. in. In other cases deep opaque reflectors are advisable. I agree with Mr. Oughton that where local lighting is provided for fine operations it is desirable to furnish supplementary overhead lighting, and for this purpose a value of not less than 0·5 foot-candles would probably suffice.

I notice that in the efficiency ratings given by Mr. Oughton the candlepower ratings are apparently based on *maximum* intensity. I feel very strongly that to-day candlepowers and efficiencies should be calculated in terms of mean spherical candlepower for upright burners and mean lower hemispherical candlepower for all classes of inverted burners. It would also be desirable, in view of the fact that the therm basis of charging for gas is now fully established, to express the specific consumption either in B.Th.U. per candle-hour or in candle-hours per Centi-Therm.

In the following table a few typical figures (recently calculated) are given :—

TYPE OF SOURCE.	SPECIFIC CONSUMPTION. B.Th.U. per Candle-hour.
"C" upright burner ..	45 (m.s.c.p. rating)
No. 4 "Kern" upright burner	38 (m.s.c.p. rating)
Universal inverted burner	25 (m.hem.c.p.)
Twin (No. 1 mantle) superheated inverted burner	19 (m.hem.c.p. rating)
Four, five and six (No. 2 mantle) superheated cluster-burners (Inverted)	16 (m. hem. c.p. rating average)
High pressure inverted burners (80 in. pressure w.g.)	11 (m.hem.c.p. rating average)

Mr. E. L. OUGHTON (*in reply*) :—

It is gratifying to have the appreciation of so eminent an illuminating engineer as the Chairman.

In reference to the importance of providing adequate illumination for dark materials in textile mills it is a simple deduction in illuminating engineering to ascertain what is needed. Yet in practice many more factors present themselves which need to be settled on the spot by the illuminating engineer, who knows how the ideal conditions of illumination can best be realised in practice. The question of varying the candlepower of lights when material of different coefficient of reflection are under manufacture is best met with rise and fall attachments by which the illumination is increased as the distance from the light source to the working plane is decreased.

Mr. Clark mentioned the shading of light sources by silica globes. In my opinion this is quite sufficient even with high pressure lighting. Textile factory lighting should have the best attention of men who understand the function of a modern gas burner, whether high or low pressure. Distant control is used with large lighting units when situated high up in the dye house, etc., but generally speaking bye-passes are deprecated owing to cost and the fact of the gas being always lighted.

As regards the prevention of dust, etc., being drawn into the burner the Keith "Group" system meets requirements, and likewise the Selas-Turner "self-burning" mixture. The absence of reference to the "Group" system was due only, as stated in the paper, to the fact that we had not any mills in our area fitted with it.

The excerpts from the Home Office Departmental report, mentioned by Mr. Mason, touch the vital spot in factory lighting, in fact, all industrial lighting, and he is on perfectly safe ground when he states that all the conditions laid down can and are met with modern gas lighting. That the operatives themselves appreciate modern lighting in factories is common knowledge to those having experience of the textile industry.

Mr. Bishop raises some very important points specially as to the rating of the lamps. I am in full agreement with him from the theoretical standpoint, but there are occasions where probably the simpler ratings are more effective in reaching the mind of the factory owner; here one speaks from personal experience. I mentioned that it was my purpose to deal with the more practical side of gas lighting in the textile industry. One knows from painful experience the difficulty many people have in assimilating the various methods of calculating the spherical and hemispherical values of light sources. It is a comparatively simple matter to arrive at the necessary illumination in foot-candles from the figure given, viz., those of the lower hemispherical polar curves.

The figures relating to the B.Th.U. per candle-hour will prove very useful to members of the Society.

PHOTOMETRY AT THE NATIONAL PHYSICAL LABORATORY.

DURING the Annual Visit to the National Physical Laboratory interesting photometric experiments were on view. These included tests of distribution of candlepower, life of electric lamps, ships' navigation lights, etc., and the relation between temperature and efficiency of tungsten filaments. The new Illumination Building is now in use and here measurements of daylight illumination for various types of rooms by means of large scale models can be made.

SOME PROBLEMS IN THE DAYLIGHT LIGHTING OF TEXTILE FACTORIES.

By P. J. WALDRAM, F.S.I.

(Paper presented at the Meeting of the Illuminating Engineering Society held at the Society of Arts, John Street, Adelphi, Monday, April 28th, 1924.)

THE subject of natural illumination in textile factories is almost too wide to be dealt with adequately even within the limits of a complete evenings' discussion. When it has to share the time available with a paper on artificial illumination by gas it is obvious that only a small branch of the subject can be surveyed.

This paper is therefore necessarily confined to the lighting needs of the cotton industry, and only so far as relates to the spinning of the raw cotton into yarn and the weaving of the latter into cloths and sheetings. The many problems arising in the spinning and weaving of flax, woollen, and worsted fabrics, hosiery, carpets, silk, etc., are left untouched, and the very important matter of electric lighting is necessarily postponed for another occasion.

The vital importance of lighting, both natural and artificial, to the cotton industry is not so fully appreciated as it should be. Text-books and authorities assure us that the predominance of Lancashire, which continually rises superior to the keenest competition, to deadly tariffs, and the overwhelming load of freight charges, both on the bulky raw material from the cotton fields and the almost equally bulky finished goods to foreign countries, is due to its natural advantages. The so-called warm and moist atmosphere of the Lancashire plain is generally given first place; then the proximity of cheap coal and iron and the engineering shops of the North, then the convenient great sea ports of Liverpool and Manchester, and finally the skill and experience of the business men of Manchester.

Doubtless, all these factors have operated in the past in building up the industry, but even an outsider can see that if Lancashire depended on them alone American, German, French, and even Indian competition, aided by the peculiar advantages of those countries, would by this time have captured much if not all of her present vast trade.

Other countries have keen business men, coal and iron in close proximity to engineering industries served with good roads, railways and canals are no monopoly of this country, and there are certainly milder climates than Lancashire at least over six months of the year.

Even the most casual observer in Lancashire cannot fail to be struck with the fact that her vaunted natural advantages can have but very little bearing on the situation to-day.

If, for instance, a warm and moist climate were essential how is it that Oldham has so many mills up on the high moors open to the north and east winds? Even Bolton, the centre of fine spinning, where probably the finest counts in the world are spun and woven, is not called Bolton-le-Moors on the old maps for nothing. It certainly has a copious annual rainfall, but it can be and often is bitterly cold in a dry wintry east wind. The writer has also frequently left a warm muggy day at Manchester and shivered considerably in Rochdale on the hills or at Preston at the north west corner.

Yet these towns do not close their mills during the winter months when the cold dry east and north winds sweep down from the hills and moors. If climate were essential one would expect the flat warm country between Liverpool and Manchester to be covered with mills, instead of being devoted as it is almost entirely to agriculture.

Coal is certainly plentiful—but few people would call it cheap, whilst iron is used as sparingly as possible in light fast-running textile machinery. Traffic facilities are, of course, essential—but road carriage is, and always has been, a great feature; yet Oldham, Rochdale and other great centres of the cotton

industry still continue to use mills approachable by stiff gradients, and to build new ones instead of moving to flatter, warmer and more humid neighbourhoods.

One must look deeper for the roots of success, and the writer ventures to suggest that they consist mainly in the unrivalled skill and experience of the Lancashire operatives; for although the cotton industry would appear at first sight to be run almost entirely by automatic machinery—skill is of first importance and Lancashire retains her pre-eminence because her skilled spinners and weavers are the finest in the world.

Payment by results has caused a community of skilled operatives to settle round each successful mill or group of mills wherever they happened to be situated. Recruited, doubtless, originally from the traditional wool spinning and weaving industry, the staple trade of the greater part of England in the middle ages, skill in cotton spinning and weaving is certainly more or less hereditary. The mills can no more afford to move away from their skilled operatives to districts with greater natural advantages than the skilled and, therefore, more highly-paid operative would dream of deserting his or her mill merely in order to work in better ventilated buildings, or to live in a more pleasant house.

It is for this reason that good lighting is not only important, but vitally essential. However perfect machinery may be, however carefully the temperature and humidity of the mills and weaving sheds may be regulated, yarns will break, and the mule, spindle or loom must be stopped to piece them. This can only be done readily in a very good light, and until the broken yarn is pieced time is lost during which very busy and very expensive machinery is standing idle, and for the time being is ceasing to earn returns for the millowner and wages for the employee.

Time was when the dark days of winter were looked forward to with dread by the operatives; not only because the cold dry winds sometimes found their way inside the mills, making the yarns lose their supple tenacity and rendering breakages more frequent, but mainly because, under the light of a flat-flame gas burner or an eight-candlepower carbon lamp, it was so difficult to find and join a broken yarn half spun or to thread a broken warp through the tiny "heald" eye, one of several hundred heald eyes, all precisely alike and all difficult to light even to-day.

One has often heard of a weaver working by artificial light in the dark hours before breakfast habitually letting one of his two or four looms stand idle until the approach of daylight enabled him to see to join and re-thread a broken yarn, and thus allow the loom to re-start.

It is, therefore, not surprising to hear that the more highly skilled spinners and weavers are always anxious to work in the mills where they will lose least time, and, therefore, earn the highest wages; and that those mills, being able to pick their workers, are the most prosperous, not only because their output is larger with the same machinery and working expenses, but also because they can work in those finer counts which demand the highest skill, command the highest prices and are scarcely produced at all in other countries.

Lancashire millowners generally are as keenly alive to the desirability of obtaining the best lighting as they are to any other factor which makes for good work—but very much still remains to be done, especially with regard to natural lighting in some of the older mills, many of which only spin coarse and cheap counts mainly because the newer and better lit mills absorb the most highly skilled operatives.

At the present time, with Lancashire working short time and suffering from the over capitalisation of the cotton boom, it is scarcely opportune to speak of additional capital expenditure, but there are doubtless many mills somewhat old, but by no means entirely out of date, which might, at a comparatively trifling cost, so improve their lighting and more particularly their natural lighting that their financial position would be vastly improved.

In order to appreciate properly the extent to which lighting is affected by the exigencies of manufacture and to follow the references in this paper it is necessary to review very briefly the processes involved between the receipt

of the cotton in bale to the finished goods.

BUILDINGS.

Spinning Mills.

The operation of spinning cotton wool into threads or yarn is almost invariably carried out in brick-built mills of several storeys, the air of which must be kept warm and moist in order that the thread may remain sufficiently supple and tenacious to withstand the drastic treatment to which it must be subjected. The finer the yarn spun, the higher the temperature must be. Yarn is designated by counts ; a count being the number of spools or hanks of thread to a given weight, low counts say 20 to 80 representing coarse yarn, whilst high counts, up to say 120, represent yarn which has been pulled out, twisted and spun into very fine threads from fine long staple at high temperatures.

The difference between coarse and fine spinning is very similar to that between wool, spun from short hair, and worsted, spun from long Merino or Leicestershire fleeces.

In all the operations of spinning the yarn is severely handled and everything must be subordinated, at least with short staple cottons, to keeping it supple and tenacious. The high temperatures and humidity required would be impossible in top-lit sheds. Side-lit rooms are the only possible structures and even in them, although adequate natural illumination is almost essential, high and equable temperature, especially in fine spinning, is absolutely so. Large windows are for this reason largely held to be ruled out by the risk of ruinously frequent yarn breakages, although practice seems to be changing in this respect. Narrow rooms would help, but the necessary length of modern mules involve widths of 140 ft., or thereabouts.

Weaving.

The operations of weaving are far less trying to the completely spun yarn, and the necessary requirements of humidity and temperature permit of them being carried out in single storey buildings still known as weaving "sheds."

The only precaution necessary is to use "north-light roofs" with the steeper or glazed side facing the north or north-east to avoid sun.

Fig. 1 shows the typical general arrangement of a storeyed spinning mill for spinning the yarn, and the typical long rows of spinning sheds where it is woven into cloth.

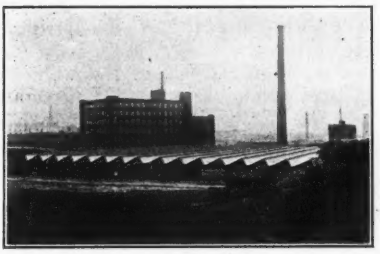


Fig. 1.—Typical Spinning Mill and rows of Weaving Sheds.

The shorter and steeper slope only of the weaving shed roof is glazed. If this faces due north and is not flatter than about 60° with the vertical all sun between 6 a.m. to 6 p.m. (nominally 7 a.m. to 7 p.m. Summer Time) would be excluded.

This is important because with such a large glass area it is even more difficult to keep down the temperature in summer sufficiently to prevent the operatives collapsing from heat exhaustion than it is to keep it up in winter sufficiently to prevent undue breakage of yarn.

An aspect for the glass side of shed roofs slightly east of north is often favoured, because the afternoon sun after 6 p.m. is hotter than the early morning sun before 6 a.m.

Needless to say many sheds have not an ideal aspect, and work is still carried on in sheds which receive very considerable sun ; whilst in others the glass faces high mill buildings and some bays have to be glazed on the flatter side.

The ventilation of cotton textile buildings, to say the least, leaves much to be desired ; and the statistics of phthisis are a ghastly comment upon the relative importance of the health of cotton and of cotton operatives. Workers are to blame no less than masters, but space forbids any digression into

this vital topic although it is closely allied to the subject of natural lighting. Suffice it to say that summer sun in practically unventilated weaving sheds speedily renders the conditions, by no means ideal at any time, unbearable, especially to women weavers.

One hears often of an unexpected advantage in pressure gas lighting—in that in summer it is possible to remove the mantles and to set the pressure pump to blow air only through the gas pipes on to the heads of the workers, a method which is said to have succeeded where cooling with lumps of ice has failed.

SPINNING.

Conditioning and Carding.

Taking the various processes in order, the bales of cotton wool are opened out and the various kinds are sorted, mixed and moistened as required at the ground floor level, and automatically conveyed to the Blowing and Scutching Room, where scraps of vegetable fibre, seeds which have escaped the ginning machinery at the cotton fields, scraps of packing, dirt and other impurities are removed. It then passes to the Card Room, which generally occupies the remainder of the ground floor of a storied mill. Here the white fleecy carpet of clean wool is "carded," *i.e.*, is submitted to a highly perfected development of the crude method of the early wool spinner, who worked his washed wool between two hand cards of leather studded with fine wire teeth, separating the matted fibres and eventually drawing them parallel.

In the important operations of carding, combing (where combed yarns are spun), drawing, etc., the cotton wool passes through numerous pairs of rollers and should be visible in transit at all stages. Finally it is stripped in pairs of rollers, alternatively toothed and smooth, which separate it into soft open strips of parallel fibres. These pass to the Draw Frames, Slubbers, Intermediate and Roving Frames where the strip is "condensed" from a sort of soft open rope known as "sliver" into a finer and finer cord or "roving."

The Card Room, Scutching Room, Conditioning Room and reception bays almost invariably occupy the whole of the ground floor and the area they require is, fortunately for the lighting, greater than that of a spinning floor above. This means that the long rectangular box of the mill proper is enlarged by sheds or one-storey buildings on at least three sides, the engine and boiler rooms generally occupying one end.

These sheds are usually top-lit—the card room proper being kept high to secure a belt of windows above the level of the shed roofs.

The Card Room windows should, like all windows in textile buildings, go right up to the ceiling. Even a slight bulk-heading of the window in the thickness of the floor, to bring the top edge of the glass flush with or even slightly above the ceiling, is desirable in order to secure the maximum amount of reflected light from the ceiling, which, needless to say, should be whitewashed as frequently as possible.

All conditioning, carding and combing operations require more vertical than horizontal light, in which they differ essentially from spinning operations.

Temperature and humidity are of first importance, but the operations are more or less automatic, and the travelling wool or sliver, although it requires frequent attention under a good light, does not demand piecing like the fine threads of spinning yarns.

In modern Card Rooms a glass area of about 9 per cent. to 10 per cent. of the floor area is generally provided.

Figs. 2 and 3 show the interior of typical Card Rooms. Fig. 3 shows the

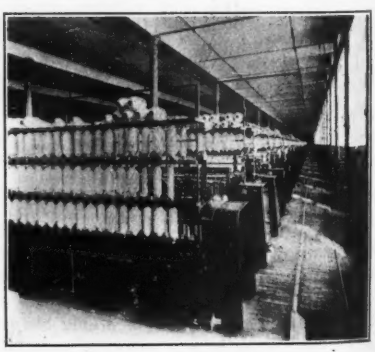


Fig. 2.—Card Room.

sliver in a thick soft cord which is condensed down to the thinner cord or "roving."

Fig. 3.—Card Room.

Spinning Floors.

The material now passes to the Spinning Floors above, where it is drawn out and twisted into "kips" or bobbins of the fine thread-like yarns from which cloth is woven. The difference between the various methods of imparting the necessary twist to the thread, originally performed by hand and foot on a spinning wheel, materially affects lighting problems. The original main developments of the old water frame or throstle perfected by Arkwright are known as "Flyer" "Cap" and "Ring" Frames. In Flyer spinning, the thread is received by a pair of small bent arms or flyers on the end of a fast-running vertical spindle. These flyer arms impart the necessary twist and wind the yarn on to a bobbin running freely on the spindle. This is very similar to the mechanism of the old hand spinning wheel.

In "Cap" and "Ring" spinning the same effect is obtained by somewhat better methods, too complicated to describe in detail, by which bobbins of "rovings" are changed in a short travel into bobbins of twisted yarn.

In none of these methods is there any movement of the rows of spindles as a whole. They are economical to floor space and the frames are comparatively short, but the friction against flyer arms, caps or rings, and the short length in which twist is imparted is somewhat severe on the yarn, so that only low counts or long staple are usually spun on ring frames, and the great bulk of cotton is spun on what are known as mule frames.

Ring Spinning.

Figs. 4 and 5 show typical ring spinning rooms, although ring spinning

Fig. 4.—Ring Spinning.

of long staple is often performed in top-lit rooms. It will be noticed that the operative has an ample working gangway along which he views his

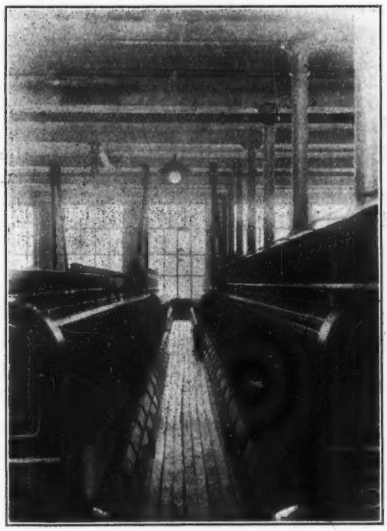


Fig. 5.—Ring Spinning.

bobbins and yarns in a more or less horizontal direction, the white threads showing up well against the dark machinery. Obviously side light between

the frames is ideal, although cross light from end windows is, as in the Card Room, no great disadvantage. Fig. 6 gives some idea of the disadvantages of a

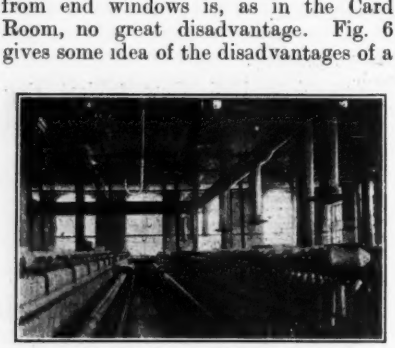


Fig. 6.—Ring Spinning.

dark ceiling which causes objectionable shadows, especially when accentuated by arched window heads and projecting beams.

Modern ring spinning frames do not exceed about 100 ft., which gives an inside width of about 110 ft. between the windows. The height of spinning floors is generally about 14 ft., the windows being made about 7 ft. wide by 9 ft. to 10 ft. high, with brick piers 3 ft. to 5 ft. wide between the windows.

These proportions give a ratio of glass area to floor area of about 9 per cent. to 10 per cent. in floors 110 ft. wide, and for ring spinning this is considered to be quite adequate.

At first sight it is difficult to see how a side-lit room 110 ft. wide and 13 to 14 ft. high can possibly be adequately

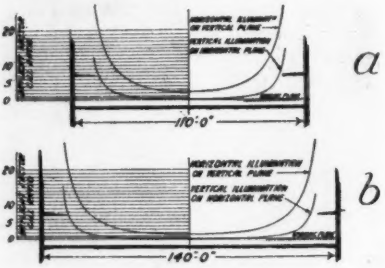


Fig. 7.

lit over its whole width, especially as the Home Office Report on the Lighting of Factories (Cd. 8000) gives examples of the variations of daylight in such rooms of the order of about 2½ per cent. to 0·02 per cent. cill ratio. But the Home Office observations were probably all taken vertically on a horizontal plane, whereas the light required for spinning floors is mainly horizontal on a vertical plane.

Fig. 7 (*a*) shows the difference between these two in a room 110 ft. wide lit on each side by windows 7 ft. wide by 9 ft. high with 5 ft. piers between the windows, or a ratio of glass to floor of about 9 per cent., and Fig. 7 (*b*) shows the same for a room 140 ft. wide.

Mule Spinning.

The special feature of the Mule spinning frame is the movable carriage to which the spindles are fixed. Fig. 8 shows the movable carriage closed in and the wheels upon which it moves in and out.

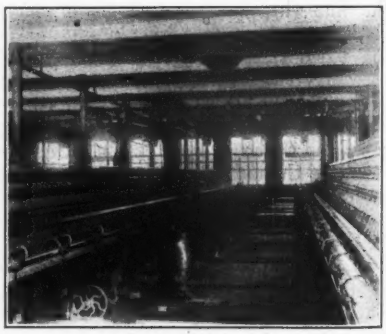


Fig. 8.—Mule Spinning.

The bobbins of condensed sliver or rovings are placed on the fixed portion of the frame, the sliver passing between a pair of rollers to the travelling spindles. These slope slightly inward and carry the tubes or spools upon which the yarn is wound. The operation starts with the tips of the spindles close to the rollers which pay out sliver as the carriage moves outwards. The spindles twist rapidly, but the yarn is prevented by a horizontal guide wire from winding on to the spindles and is therefore merely twisted. When the carriage has moved out for part of its travel the paying out ceases and the spindles turn faster so that the yarn is elongated and twisted simul-

taneously (Fig. 9). When enough twist has been given the spindles may take a few turns in the opposite direction to unwind any short length of yarn which may have coiled round the spindle top, the guide

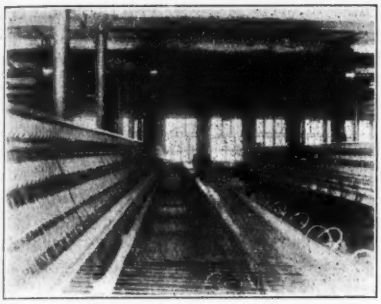


Fig. 9.—Mule Spinning.

wire drops and is followed by a second which, as the travelling frame slides home again, forces the now twisted yarn to wind evenly on the rapidly revolving bobbin. The operation is then repeated until the sliver bobbins need renewal.

In this operation again horizontal light is particularly needed, and the ease with which one can detect a single broken yarn out of some 1,000 to 1,300 across a 140 ft. room is surprising.

On account of the length of the modern mule, rooms 130 to 140 ft. wide are essential. There would probably be 10 to 12 bays of some 21 ft. to 22 ft. wide. The difficulties of keeping a high and equable temperature in rooms of these huge dimensions are obvious if the glass area is great. Attempts to use practically continuous windows are said to have failed because of the severe cooling of the air round the ends of the mules. But the old 5 ft. to 5 ft. 6 in. brick pier between every pair of windows can be reduced. Even for fine spinning a ratio of 7·7 per cent. of glass to floor is found in one of the newest and most successful mills, and in a very modern mill at Oldham, spinning low counts, I have found as much as 8 per cent. in a 140 ft. mule room (Fig. 10). Fig. 11 shows the Cairo mill at Oldham where the ratio is 11·8 per cent.

The lower squares of the windows are almost invariably glazed with hammered plate. This is said to give a soft diffused light surface against which to view the long lines of yarn. But as one does not view the yarns against the glass, but against a dark floor there would appear to be more to be said for the alternative

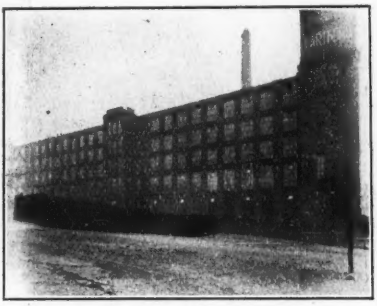


Fig. 10.—Hartford Mill, Oldham.

reason, that such glass prevents a clear view and the workers' attention is not distracted.

It will be obvious that end windows in Mule Spinning rooms which throw cross lights between the spindles and destroy the contrast between the light yarn and the dark floor, are better omitted, especially in a south wall where

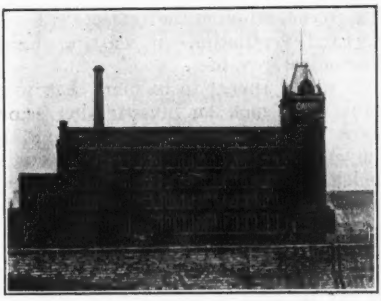


Fig. 11.—Cairo Mill, Oldham.

the sun's rays are apt to scorch and even char the frame woodwork in highly heated rooms.

When long modern mules are installed in old 40 ft. or 50 ft. mills (Fig. 12) they have to be placed parallel with the windows so that the lighting is wholly wrong. The only favourable feature is that the windows of the oldest mills are so small, so obscured by thick wooden bars, and the glass is so decayed and dirty, that it is generally

too subdued to cast strong shadows. Otherwise the mixture of artificial and natural lighting in such mills would be unbearable. At present it is merely horrible.

Fig. 12.—Old Type of Spinning Mill.

There is, however, no reason why such old mills should not be lit by properly designed windows cut in the end walls.

Generally the whole question of the lighting of very wide mule rooms is in a most unsatisfactory state. There is little or no data of any value—authorities differ largely, and the subject would well repay further study. This should be based on horizontal instead of vertical illumination, and corelated closely with due consideration of the subjects of heating and ventilation—at least of Kata thermometer values.

It would appear to be more than probable that such an investigation would show the feasibility of systems of air movement as distinct from air renewal; which would not only give far healthier conditions and greater comfort in the summer, but would equalise the temperature, vastly improve the natural lighting and reduce the yarn breakages; to say nothing of reducing the greatest wastage of all—that of human life by consumption amongst the operatives.

Weaving.

By the time the yarn reaches the Weaving Shed, its serious troubles are over. Moderate temperatures only are required, and the large glass areas and bright steady light is the perfection of natural illumination. But even in weaving sheds there are points to be considered.

The warp threads in a loom stretch horizontally from a back roller towards a front roller, which receives the finished cloth. After leaving the back roller the threads pass individually through small wire eyes known as "healds" in the length of vertical cords, and then between the vertical wires of a frame at right-angles to the warp threads, which can be moved backwards and forwards and known as the "Sley" or batten.

If by suitable mechanism the even numbered healds are raised and the odd numbers pulled down, the warp threads open alternately up and down leaving a V-shaped space or shed. Through this space the shuttle containing the weft thread is shot across, leaving a trail of weft thread behind it.

The sley now rocks over and pushes this thread to the apex of the V, where it becomes part of the finished cloth. The even numbered healds are then pulled down, the odd numbers raised, and a similar "shed" is formed at the apex of which the last drawn weft thread is locked into the finished cloth—the shuttle returns, again leaving its trail of weft thread which is pushed forward by the sley, and the whole process proceeds automatically.

This, of course, is the very simplest elementary plain weaving; but even plain looms are very beautiful pieces of automatic machinery—stopping immediately a warp thread breaks, and even changing and refilling their own shuttles.

To pick up and piece a broken warp thread is no easy matter, and if a weaver is to keep four looms going on closely woven materials like aeroplane fabric, good light is essential, not only on the stretch of warp threads, but more especially in the dark recesses of the loom in behind the healds.

The mistake is often made of placing the looms parallel with the glass. This gives an excellent light on the stretch of warp, and the shuttles and on the sley and the front of the healds, and artificial light often comes from the same direction. But what is wanted is light on *both* sides of the healds. When the loom is fitted with complicated mechanism for fancy weaving, the space from the back roller to the back of the healds is greatly obscured by dobbies or Jacquard harness,

INDEX, May, 1924.

PAGE

Editorial. By L. GASTER 61

Illuminating Engineering Society—
(Founded in London, 1909)

Account of Meeting on Monday, April 28th, 1924 65

Some Notes on Gas Lighting in the Textile Industry. By ERNEST L. OUGHTON 66

Discussion—Mr. L. GASTER (Chairman)—Mr. J. G. CLARK—Mr. W. M. MASON—Mr. W. A. BISHOP 75

Some Problems in the Daylight Lighting of Textile Factories. By P. J. WALDRAM, F.S.I. 79

Illuminating Engineering Society (U.S.A.), Forthcoming Convention 80

TOPICAL AND INDUSTRIAL SECTION 80

and the most vital operation of all, rethreading broken warp yarns quickly, must then be done half in bright light and half in shadow.

The proper position for looms is at right angles to the roof glass, not only to get light in behind the healds and under the Jacquard harness, but also in plain looms to see plenty of the quickly woven finished cloth at the front of the cloth roller so that defects may not pass away unnoticed into the roll of fabric.

The artificial lighting of weaving sheds is not my province this evening, but I venture to suggest that unless or until the back of the healds can be illuminated, spinning by artificial light will never be satisfactory.

Beaming, Twisting and Healding.

One last word on behalf of a glass of skilled operatives whose work is of the utmsot importance in weaving, viz., those who wind the warp threads on to the back roller or beam, thread them through the healds and through the sleys and arrange the bobbins of weft for fancy weaving. In fact, those who carry out all the tedious but essential operations of preparing a delicate automatic machine to perform its almost human functions.

These men being numerically very few in any one mill are only too often given any odd ill-lighted space to work in; although the work of no one about a mill demands such unremitting and skillful concentration, and few cotton workers suffer so much from eye strain. The only prospect which would reconcile the writer to being a cotton magnate would be that of being able to visit mills, to go straight to the Beamers' room and then to have a heart to heart talk with the management.

Generally the author submits that opinion in Lancashire as to what amount of natural lighting can or cannot be afforded in cotton spinning is so contradictory, and is often so opposed to successful practice, that the whole subject —vital as it is to one of our greatest industries—urgently demands complete and exhaustive inquiry.

If it should be that the fear of excessive yarn breakage, which in the past has restricted window areas, is ill-founded or exaggerated, and that more daylight can be admitted to mills, and particularly to mule spinning floors, then that fact cannot be made known too soon nor too widely.

ILLUMINATING ENGINEERING SOCIETY (U.S.A.)

Plans for the Forthcoming Annual Convention.

WE are informed that the Annual Convention of the Illuminating Engineering Society (U.S.A.) will be held during October 27th-31st at Briarcliff Lodge, Briarcliff Manor, New Jersey. Briarcliff Lodge is situated amidst pleasing scenery and is considered an excellent site for the Convention. We understand that a very varied series of papers has been secured and that the list of subjects includes Daylight Illumination in Factories; Colour Standards and Nomenclature; The Effect of Light on Plant Growth; Store, Window and Showcases Lighting; Theatrical and Decorative Lighting; Street Lighting Practice in the United States; School Lighting; Light and Speed or Vision; the Psychology of Light and Colour; Glare; Defects of Vision in Industrial Work, etc.

TOPICAL AND INDUSTRIAL SECTION.

[At the request of many of our readers we have extended the space devoted to this Section, and are open to receive for publication particulars of interesting installations, new developments in lamps, fixtures, and all kinds of apparatus connected with illumination.

The contents of these pages, in which is included information supplied by the makers, will, it is hoped, serve as a guide to recent commercial developments, and we welcome the receipt of all *bona-fide* information relating thereto.]

X-RAY REFLECTORS.

A BOOKLET issued by the British Thomson Houston Co., Ltd., illustrates a variety of X-Ray reflectors suitable for shop-window lighting. Special interest attaches to the "X-Colour-Ray" attachment in which a sheet of coloured glass can be interposed in front of the lighting units, enabling varied colour effects to be obtained. The booklet is illustrated by a number of photographs of artificially lighted show wondows and particulars of the Beehive and other types of reflectors are included.

THE USE OF TOWN GAS IN INDUSTRY.

SIR ARTHUR DUCKHAM'S paper on the above subject, presented at the First World power Conference at the British Empire Exhibition, has been reprinted in pamphlet form and copies may be obtained from the British Commercial Gas Association (30, Grosvenor Gardens, London, S.W.1). In an appendix to the paper an imposing list of industries in which gas finds useful applications is given. In many cases gas is used as a heating agent but the numerous illustrations includes several views of lighting installations, especially in connection with printing works and the textile industries.

A NEW GUIDE TO WEMBLEY.

WE have received a copy of the new Official Guide to the British Empire Exhibition which in several respects is in advance of its predecessor and contains some additional information. There are a number of attractive illustrations of the chief buildings, on each of which brief notes are included, and the reader is offered alternative plans for doing Wembley in one or three days. It is, however, common experience that the Exhibition contains a good deal more than can be seen in even three visits, and therefore the third scheme of "doing" Wembley in a week" will also be welcome. The guide contains several clear maps of the Exhibition and should be of considerable aid to visitors.